



DEPARTMENT OF THE AIR FORCE  
59TH MEDICAL WING (AETC)  
JOINT BASE SAN ANTONIO - LACKLAND TEXAS



20 MAR 2017

MEMORANDUM FOR SGO

ATTN: CAPT ADRIAN R BERSABE

FROM: 59 MDW/SGVU

SUBJECT: Professional Presentation Approval

1. Your paper, entitled **Peripheral Smear Review and Bone Marrow Biopsy Correlation** presented at/published to **Journal of Clinical and Diagnostic Research (Publication & Abstract)** in accordance with MDWI 41-108, has been approved and assigned local file #17143.
2. Pertinent biographic information (name of author(s), title, etc.) has been entered into our computer file. Please advise us (by phone or mail) that your presentation was given. At that time, we will need the date (month, day and year) along with the location of your presentation. It is important to update this information so that we can provide quality support for you, your department, and the Medical Center commander. This information is used to document the scholarly activities of our professional staff and students, which is an essential component of Wilford Hall Ambulatory Surgical Center (WHASC) internship and residency programs.
3. Please know that if you are a Graduate Health Sciences Education student and your department has told you they cannot fund your publication, the 59th Clinical Research Division may pay for your basic journal publishing charges (to include costs for tables and black and white photos). We cannot pay for reprints. If you are a 59 MDW staff member, we can forward your request for funds to the designated Wing POC at the Chief Scientist's Office, Ms. Alice Houy, office phone: 210-292-8029; email address: [alice.houy.civ@mail.mil](mailto:alice.houy.civ@mail.mil).
4. Congratulations, and thank you for your efforts and time. Your contributions are vital to the medical mission. We look forward to assisting you in your future publication/presentation efforts.

*Linda Steel-Goodwin*

LINDA STEEL-GOODWIN, Col, USAF, BSC  
Director, Clinical Investigations & Research Support

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Peripheral Smear Utilization Within a Hematology/Oncology Fellowship Program

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b. James K. Aden	CIV	CIV	BAMC
c. Nathan M. Shumway	CIV	CIV	Texas Oncology
d. Michael B. Osswald	CIV	CIV	BAMC
e.			

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Adrian R. Bersabe, Capt., O3

19. AUTHOR'S SIGNATURE

BERSABE ADRIAN R. 1176528180

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9 March 2017

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42. PRINTED NAME, RANK/GRADE, TITLE OF REVIEWER Kevin Iinuma, SSgt/E-5, 59 MDW Public Affairs	43. REVIEWER SIGNATURE IINUMA KEVIN MITSUGU. 1296227 613 <small>Digitally signed by IINUMA KEVIN MITSUGU. 1296227613 DN: cn=IINUMA KEVIN MITSUGU. 1296227613, ou=HHS, ou=USAF Date: 2017.03.16 11:00:51 -0500</small>	44. DATE March 16, 2017
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# Peripheral Smear Review and Bone Marrow Biopsy Correlation

Adrian R. Bersabe<sup>1</sup>, James K. Aden<sup>2</sup>, Nathan M. Shumway<sup>3</sup>, Michael B. Osswald<sup>4</sup>

## ABSTRACT

**BACKGROUND:** Peripheral blood smear (PBS) interpretation is a useful skill for Hematology/Oncology clinicians (HOC).

**AIM:** To explore practice patterns of PBS utilization for all benign hematology diagnoses in a non-simulated environment and to evaluate how it may guide the HOC in determining further work-up and whether or not to perform a bone marrow biopsy (BMB).

**METHODS:** A retrospective review was conducted on 451 outpatient referrals for benign hematology diagnoses. Patient demographics and diagnostic tests were recorded. We further analyzed cases in which a blood smear was ordered or reviewed. In cases with PBS review, we recorded testing ordered by the HOC.

**RESULTS:** Records of 451 patients met inclusion criteria. The median age was 55 with males representing 51.9% of the cohort. Distribution of disorders were 50.6% (n = 228) erythrocyte (RBC),

25.5% (n = 114) leukocyte (WBC), 11.3% (n = 51) platelet (PLT), and 12.8% (n = 58) "other." A CBC was ordered in 82.7% of cases (373/451). A PBS was ordered in 47.4% of CBCs obtained (177/373,  $p < 0.0001$ ). Of these, documentation occurred in 49.2% (87/177) which led to further testing 41.4% of cases (36/87). A BMB was performed in 11.5% (10/87) of cases in which a PBS was reviewed compared to 4.3% (16/373) of cases where BMB was performed without PBS review ( $P = .019$ ).

Of the 36 cases in which PBS review led to testing, 10 BMBs (27.8%) were performed—all of which led to specific hematologic diagnoses. A specific diagnosis was found in 43.8% (7/16) BMBs performed without prior PBS review.

**CONCLUSIONS:** PBS interpretation is an important skill for HOCs. Hematology/Oncology (H/O) training programs should continue to teach this skill to increase proficiency in order to help guide diagnostic evaluation of various hematologic disorders.

**KEY WORDS:** Erythrocyte, Leukocyte, Blood Platelets, Peripheral Blood, Bone Marrow Biopsy

## INTRODUCTION

The practice of peripheral blood smear (PBS) interpretation is an extremely important diagnostic skill in the subspecialty of Hematology/Oncology (H/O) and enhances the clinicians' understanding of how to appropriately interpret laboratory results in conjunction with the entire clinical picture [1, 2]. PBS examination may provide further insight into the etiologic basis of many hematologic conditions such as various etiologies of anemias and hemoglobinopathies. Physician review of the a PBS can also be helpful in cases of platelet disorders,

leukemias, lymphomas, and bone marrow failure as distinct abnormalities may be noted leading to timely and accurate diagnosis, further evaluation, and potential treatment [1, 3, 4, 5, 6, 7, 8, 9]. Bone marrow biopsies (BMB) are another important procedural skill used by Hematology/Oncology clinicians (HOC) for the evaluation of both hematologic and non-hematologic disorders. Depending on the clinical presentation, and sometimes, PBS interpretation, a clinician may determine if a BMB is indicated [10].

There has been a relatively recent push for hematologists to make it regular practice to become

more proficient in routinely reviewing and correctly interpreting peripheral smears [11]. However, in today's era of sophisticated automated blood cell-analyzers, routine analysis of blood smears by clinicians is becoming less common. Over the past century automated hematology analyzers have decreased the proportion of blood-count samples that require peripheral smear review [3, 12, 13]. Common laboratory practice is to review only specimens that the automated instruments have flagged for review due to distributional, morphologic, or instrumental error. In these instances an experienced laboratory technician followed by an assistant laboratory manager and/or a hematopathologist reviews the sample that later disseminates the information to the clinician [2, 3, 7, 8, 11]. Thus, many ordering clinicians, now rely on the laboratory for accurate interpretation of the PBS by qualified laboratory technologists and/or hematopathologists as this routine practice can be time consuming and labor-intensive [2, 3, 7, 14].

To our knowledge, there is currently no literature describing how often HOCs in an accredited training program routinely interpret PBS or how often their interpretations lead to further diagnostic studies. However, one study by Simmons, et. al. simulated the initial work-up of common anemias wherein 65 clinicians were asked to review 12 case histories and subsequently review associated peripheral smears. They were then asked to identify morphologic features on the PBS and then instructed to select from a list their diagnoses and work-up plans based on the available information and their interpretation of the PBS. Presence or absence of morphologic findings in PBS review was correctly identified 82% of the time. These authors reported that the number of further diagnostic tests was not affected by PBS review suggesting that this skill does not add value to the work-up of common anemias [15].

The aim of this study was to explore practice patterns of PBS utilization for all benign hematology diagnoses in a non-simulated environment and to evaluate how it may guide the HOC in determining further work-up and whether or not to perform a BMB. Furthermore, in the cases where a BMB was performed, we examined the correlation of abnormal bone marrow results with

the clinician's documentation of abnormal PBS findings. Practice patterns between staff and fellow HOC were also compared.

## METHODS

A retrospective review was conducted on 474 consecutive, initial outpatient referrals for benign hematology diagnoses (ICD-9 codes 280-289) evaluated by seven staff physicians and nine fellows from Aug 2011 to May 2012. Adults from age 18 to 85 were included. Patient demographics and diagnostic tests were recorded. In cases with PBS review, we recorded further testing ordered by the HOC. We also assessed whether staff or fellow clinicians were more likely to review and document their PBS findings. 23 patients were excluded due to age criteria or no data was available within the electronic medical record (EMR).

The probability of events in the ordering and review of blood smears in an accredited H/O fellowship program was reported as the estimate of a binomial probability and its 95% confidence interval. The data was summarized using percentages and counts. Chi-Squared tests or Fisher's Exact test were used for analysis whichever is most appropriate. Significance for results was established when p-values were less than 0.05.

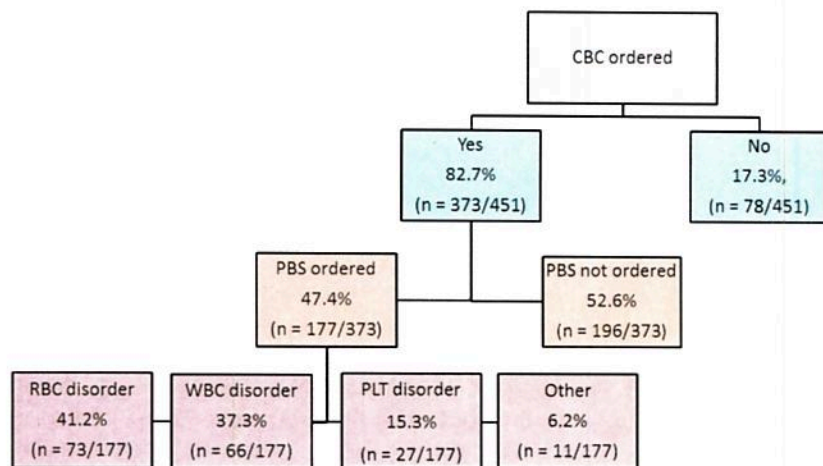
## RESULTS

Four hundred and fifty-one records met inclusion criteria. Patient demographics and distribution of diagnoses by peripheral blood cell type are presented in [Table/Fig 1]. The five most common diagnoses were anemia, unspecified (n = 96, 21.3%), iron deficiency anemia (n = 64, 14.2%), leukocytosis, unspecified (n = 49, 10.9%), thrombocytopenia (TCP), unspecified (n = 48, 10.6%), and leukopenia, unspecified (n = 21, 4.7%). A CBC was ordered in 82.7% cases (373/451). A PBS was ordered in 47.4% of cases that the provider ordered a CBC. A PBS was most likely to be ordered for RBC disorders when compared to WBC disorders, PLT disorders, and "other" diagnoses as depicted in the flow diagram,  $P < .0001$  (Table/Fig-2). HOCs documented their PBS findings within the EMR in 49.2% of cases in which

they were ordered. Two hundred and twenty-nine CBCs were ordered by seven staff physicians, and 138 CBCs were ordered by nine fellows during the period of this review. There was no significant difference in practice patterns of ordering a PBS between staff (45.9%, 105/229) and fellow physicians (52.2%, 72/138),  $P = 0.28$ . The likelihood that a staff physician documented their PBS findings (51.4%, 54/105) did not differ from the likelihood that fellows documented their PBS findings (45.8%, 33/72),  $P = 0.54$ .

**[Table/Fig 1]: Demographics of outpatient benign hematology referrals**

number of records studied	451
Age(median)	55
Male	234 (52%)
Race/Ethnicity	
Caucasian	200 (44%)
African American	106 (24%)
Other	145 (32%)
Diagnosis	
Erythrocyte (RBC) disorders	228 (51%)
Leukocyte (WBC) disorders	114 (25%)
Platelet (PLT) disorders	51 (11%)
Other	58 (13%)



**[Table/Fig 2]: CBC and PBS ordered for outpatient benign hematology referrals**

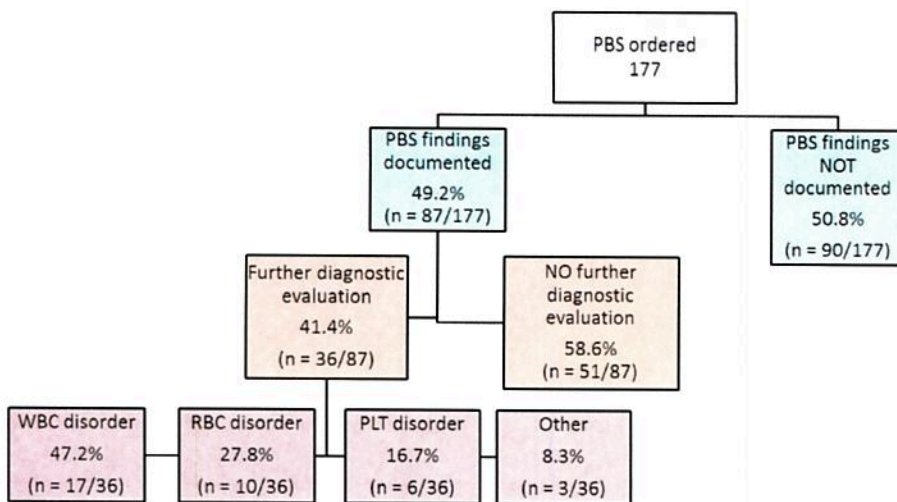
Further diagnostic evaluation with laboratory testing, imaging, and/or other specialty referral occurred in 41.4% of cases that HOC ordered a PBS and specific findings were documented. This

represented 8% (36/451) of the entire cohort. Of the 36 cases in which PBS review led to testing, 10 (27.8%) were RBC disorders, 17 (47.2%) were WBC disorders, 6 (16.7%) were PLT disorders, and 3 (8.3%) were categorized as “other” [Table/Fig 3]. Additional non-laboratory tests included one Gastroenterology referral for anemia, an ultrasound to evaluate for splenomegaly, and 10 BMBs.

A BMB was performed in 5.8% (26/451) of all initial benign hematology referrals. Of the BMBs performed after PBS interpretation (11.5%, 10/87), one was obtained for a RBC disorder showing primary myelofibrosis (PMF). Four BMBs for WBC disorders revealed two cases of chronic myelocytic leukemia, one myeloproliferative disease, and one toxin-mediated marrow suppression. Three BMBs performed for low PLTs aided in the diagnoses of aplastic anemia, idiopathic thrombocytopenia purpura, and large granular lymphocytic leukemia. The BMBs performed for two cases in “other” diagnoses carried ICD-9 codes for splenomegaly and monoclonal gammopathy of undetermined significance (MGUS), and the BMB confirmed PMF and MGUS.

In 4.3% of cases (16/373), the HOC performed a BMB without prior PBS review. Of these, four (25%) were initially referred for a RBC disorder with a BMB leading to the diagnosis of T-cell LGL leukemia. Five (31.3%) were referred for a WBC disorder revealing one case of chronic lymphocytic leukemia and another lymphocytic eosinophilia. Four (25%) were referred for thrombocytopenia with BMB aiding in the diagnoses of myelodysplastic syndrome, ITP, and metastatic stage IV carcinoma of unknown primary. Lastly, three of these referrals were categorized as “other” with BMB confirming the diagnosis of multiple myeloma in one case. Thus, a specific diagnosis was found in 43.8% (7/16) of BMB performed without prior PBS review. A BMB was more likely to be performed and more likely to be diagnostic after HOC PBS review than without PBS review ( $P = 0.0265$ ,  $P = 0.012$ , respectively).

**[Table/Fig 3]: PBS and further diagnostic evaluation for outpatient benign hematology referrals**



## DISCUSSION

Examination of the PBS is an important skill for clinicians—especially Hematologists [3, 11, 16]. Various case reports also highlight the significance of PBS evaluation aiding in the diagnosis of rare or difficult cases as well as cases requiring immediate diagnosis and treatment [17, 18, 19, 20]. However, some authors suggest that PBS review may not be as useful and may even lead the clinician to order more inappropriate tests. This was seen particularly in common anemia diagnoses such as iron deficiency, vitamin B12 deficiency, and thalassemias [15, 21].

This retrospective study sought out to describe practice patterns of PBS utilization for benign hematology referrals by HOCs at an accredited H/O training program. We investigated the frequency in which the HOC ordered and actually documented their interpretation of the PBS within the EMR and the likelihood that this clinical skill led to further evaluation and/or diagnosis. A CBC was ordered in the majority of benign hematology referrals, and of these, a PBS was ordered in less than half of cases. HOC documentation of PBS findings occurred in less than half of cases that it was determined PBS review should be done. The HOC was significantly more likely to order a PBS for disorders relating to RBC, followed by WBC, PLTs, and “other” diagnoses, respectively. The likelihood of HOC documentation of PBS interpretation did not differ based on the hematologic diagnosis, and there were no significant differences in PBS ordering or documentation of PBS findings between staff and fellow providers.

Further diagnostic testing was ordered in nearly half cases (41.4%) in which the HOC documented PBS findings. A BMB was ordered in close to a third of these cases, and a definitive diagnosis was made in all BMBs obtained after PBS examination. However, when a BMB was performed without prior PBS review, definitive marrow findings were seen in less than 50% of cases. There was a higher likelihood that BMB was more likely to be performed and lead to a specific hematologic diagnosis after

HOC PBS review than without PBS review.

Microscopic examination and interpretation of a PBS serves to ensure that no clinically significant finding is missed and to aid in accurate diagnosis—especially when interpreted by a hematopathologist, pathologist, or hematologist with training and experience [22]. It should be noted that interpretation of PBS is a requirement by the Accreditation Council for Graduate Medical Education (ACGME) in Hematology fellowship programs. To our knowledge, however, there are no standardized criteria for PBS review within H/O training programs. Other than an abnormal CBC and differential, which are the major determinants leading to PBS review, there are other factors such as clinician concerns and level of reviewer training and experience which may lead to PBS review [22]. The level of training of the HOC did not seem to impact the likelihood of PBS review in this study, however.

Some limitations of this review include those that are commonly inherent of retrospective studies. Furthermore, the HOC often did not provide specific reasoning regarding why or why not a PBS was ordered, and if ordered, why specific PBS findings were not documented in the EMR. Lastly, we did not evaluate whether or not PBS review led cost-effective diagnostic evaluation.

## CONCLUSION

While many may agree that clinician examination of the PBS may not be necessary in all benign hematology consultations, our data suggests that the practice of PBS interpretation remains an important

and useful skill for HOCs. In our study, we found that the diagnostic yield of a BMB was higher when prior PBS was reviewed led to the decision to perform the procedure. This data suggests that review of the PBS by clinicians may aid in more appropriately identifying patients for BMB in order to obtain a definitive diagnosis. Hematology/Oncology training programs should continue to teach this skill and work to become more experienced in PBS interpretation to guide diagnostic testing and potential management of various hematologic disorders.

**Authors disclosure of potential conflict of interest:** The authors of this study have no potential conflicts of interest to disclose or report.

**Acknowledgements:** None

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